TIME TABLE

(Registration on Monday at 8:30)

TIME	Monday	Tuesday	Wednesday	Thursday	Friday
	June 21	June 22	June 23	June 24	June 25
9.00 - 9.45	Ruzzene	Deymier	Jensen	Vakakis	Romeo
9.45 - 10.30	Ruzzene	Deymier	Jensen	Vakakis	Romeo
11.00 - 11.45	Movchan	Ruzzene	Romeo	Ruzzene	Romeo
11.45 - 12.30	Movchan	Ruzzene	Romeo	Ruzzene	Romeo
14.30 - 15.15	Movchan	Deymier	Jensen	Vakakis	
15.15 - 16.00	Movchan	Deymier	Jensen	Vakakis	
16.30 - 17.15	Movchan	Deymier	Jensen	Vakakis	
17.15 - 18.00	Movchan	Deymier	Jensen	Vakakis	

ADMISSION AND ACCOMMODATION

Applicants must apply at least one month before the beginning of the course. Application forms should be sent on-line through our web site: http://www.cism.it or by post.

A message of confirmation will be sent to accepted participants. If you need assistance for registration please contact our secretariat.

The 700,00 Euro registration fee includes a complimentary bag, four fixed menu buffet lunches (Friday not included), hot beverages, on-line/downloadable lecture notes and wi-fi internet access.

A limited number of participants from universitites and research centres who are not supported by their own institutions can be offered board and/or lodging in a reasonably priced hotel. Requests should be sent to CISM Secretariat by **April 21, 2010** along with the applicant's curriculum and a letter of recommendation by the head of the department or a supervisor confirming that the institute cannot provide funding. Preference will be given to applicants from countries that sponsor CISM.

The Deutscher Akademischer Austausch Dienst (DAAD) and the Deutsche Forschungsgemeinschaft (DFG) offer support to German students. Please contact:

DAAD, Kennedyallee 50, 53175 Bonn
tel. +49 (228) 882-0
e-mail: postmaster@daad.de
web site: http://www.daad.de/de/kontakt.html

DFG, Kennedyallee 40, 53175 Bonn
tel. +49 (228) 885 2655
e-mail: ing4@dfg.de
web site: http://www.dfg.de

Information about travel and accommodation is available on our web site, or can be mailed upon request.

For further information please contact:

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Palazzo del Torso - Piazza Garibaldi 18
33100 Udine (Italy)
tel. +39 0432 248511 (6 lines)
fax +39 0432 248550
e-mail: cism@cism.it

Centre International des Sciences Mécaniques
International Centre for Mechanical Sciences

ACADEMIC YEAR 2010
The Lippmann Session

WAVE PROPAGATION IN LINEAR AND NONLINEAR PERIODIC MEDIA: ANALYSIS AND APPLICATIONS

Advanced School
coordinated by

Francesco Romeo
Università di Roma "La Sapienza"
Italy

Massimo Ruzzene
Georgia Institute of Technology,
GA, USA

Udine, *June 21 - 25,* 2010

WAVE PROPAGATION IN LINEAR AND NONLINEAR PERIODIC MEDIA: ANALYSIS AND APPLICATIONS

Periodic structural configurations are ubiquitous: many heterogeneous structures and materials, both man-made and naturally occurring, feature geometry, micro-structural and/or materials properties that vary periodically in space. The classes of periodic materials and structures span a wide range of length scales, and a broad range of applications. Periodic trusses, periodically stiffened plates, shells and beam-like assemblies can be found for example in many civil, aerospace, mechanical and ship constructions. Their introduction is mostly motivated by structural strength and weight requirements. However recent studies have shown how the periodicity can be exploited to attenuate, isolate and localize vibrations. Such studies explore the unique ability of periodic assemblies to impede the propagation of elastic waves over specified frequency bands, within which strong attenuation of vibration and radiated noise can be achieved. The attenuation levels that can be obtained through tailored structural periodicity far exceed the performance of most energy dissipation and damping mechanisms. For this reason, passive, active and hybrid periodic structural configurations are being proposed for the reduction of vibration transmission and structure-born, as well as airborne noise. In addition, the understanding of the dynamics of periodic structures is essential for the analysis of bladed disc assemblies which are found in turbo machinery and in turbines for energy generation, where failure mechanisms due to localization phenomena may occur.
At much smaller scales, extensive research is being devoted to the analysis and design of phononic metamaterials for a variety of applications. Phononic metamaterials are essentially periodic structural configurations obtained through composite design, featuring periodic modulations of mass and stiffness properties, or elastic lattice structures. Gigahertz communication devices, such as mobile phones, use phononic-based systems for their low-power filtering characteristics. Many sensing devices based on resonators, acoustic logic ports, and surface acoustic wave-based filters rely on the unique band gap characteristics of periodic phononic materials. These properties are associated with the destructive and constructive interference of acoustic waves originating at the periodic interfaces, which produce frequency band of strong attenuation of acoustic waves (band gaps). Depending on the inclusions, geometry, and elastic properties, one can design for specific band gaps.
In photonic crystals, periodic modulations of the dielectric properties of a medium allow guiding, focusing and steering of electromagnetic waves. Properties modulations and engineered anisotropy in heterogeneous media can also produce negative refractive indexes, both in photonics as well as in phononic metamaterials, which lead to super-lensing or super-focusing characteristics. Other potential implications of the “acoustic wave guiding” technology include active sensing of structural integrity, smart sensing of environment, dissipation of high frequency modes of vibration to enhance vehicle performance or stealth, as well as applications to the medical field for sensing or diagnostic applications.
The aim of the course is to present both the theoretical background and an overview of the state-of-the art in wave propagation in linear and nonlinear periodic media in a consistent lecture format.
The course is intended for doctoral and postdoctoral researchers in civil and mechanical engineering, applied mathematics and physics, academic and industrial researchers, which are interested in conducting research in the topic.

PRELIMINARY SUGGESTED READINGS

Brillouin, L. 1953. Wave Propagation in Periodic Structures, 2nd ed. Dover, New York.

D.J. Mead, Wave propagation in continuous periodic structures: research contributions from southampton, 1964–1995, Journal of Sound and Vibration, 190(3), 495-524, 1996.

Kittel, C., Introduction to Solid State Physics, 8th ed. John Wiley & Sons, Inc., 2005.

Manevitch L.I., Pervouchine V.P. Transversal dynamics of one-dimensional chain on nonlinear asymmetric substrate. Meccanica, 38, 669-676, 2003.

Gonella S., Ruzzene M., “Homogenization and Equivalent In-Plane Properties of Two-dimensional Lattices”, International Journal of Solids and Structures, 45, n 10, 2897-2915, 2008.

Romeo F., Rega G., Wave propagation properties of chains of oscillators with cubic nonlinearities via nonlinear map approach, Chaos, Solitons and Fractals, 27, 606-617, 2006.

Sigmund O. and Jensen J.S., Systematic design of phononic band-gap materials and structures by topology optimization, Philosophical Transactions of the Royal Society: Mathematical, Physical and Engineering Sciences, 361, 1001–1019, 2003.

C. Daraio, V.F. Nesterenko, E.B. Herbold, S. Jin, Tunability of solitary eave properties in one-dimensional strongly nonlinear phononic crystals, Physical Review, E 73, 026610, 2006.

Khelif, A., et al., Complete band gaps in two-dimensional phononic crystal slabs. Physical Review E - Statistical, Nonlinear, and Soft Matter Physics, 2006. 74(4): p. 046610.

INVITED LECTURERS

Jacob S. Jensen - Technical University of Denmark, Denmark
6 lectures on: Topology optimization of phononic and photonic crystals. Finite element modeling of wave propagation in finite crystal structures. Computation of wave intensity, transmission, reflection and dissipation. Sensitivity analysis using the adjoint method. Optimization tools, examples and experiments.

Pierre Deymier - The University of Arizona, USA
6 lectures on: Analysis and design of phononic crystals and acoustic metamaterials. Theoretical and numerical tools for PC (Plane wave expansion method, FDTD, FE). Unusual acoustic effects: negative refractions, tunneling, cloaking. Examples and experimental results.

Alexander Movchan - University of Liverpool, UK
6 lectures on: Highly nonlinear periodic systems. Discrete to continuum approaches. Role of defect, randomization and dissipation in the localization. Experimental results and applications.

Francesco Romeo - Università di Roma "La Sapienza", Italy
6 lectures on: Classical approaches for linear periodic systems: receptance and transfer matrices, wave vector approaches. Invariant representation of propagation properties and applications to vibration transmission reduction. Waves in nonlinear periodic media. Maps for nonlinear oscillatory chains. Nonlinear propagation properties, bifurcation analysis and localized solutions.

Massimo Ruzzene - Georgia Institute of Technology, GA, USA
6 lectures on: Overview on periodic structures and media. Basic concepts in wave propagation. Structural lattices theoretical background and lattice descriptions. Bandgaps and directionality. Equivalent properties of structural lattices. Smart and tunable structures: rods, beam and plates with periodic shunted piezo arrays: application to vibration/noise control and to the design of tunable metamaterials.

Alexander F. Vakakis - University of Illinois at Urbana - Champaign, IL, USA
6 lectures on: Asymptotic techniques and analytical solutions. Waves in nonlinear layered media: perturbation approaches, nonlinear localization and targeted energy transfer phenomena.

LECTURES

All lectures will be given in English. Lecture notes can be downloaded from CISM web site, instructions will be sent to accepted participants.

WAVE PROPAGATION IN LINEAR AND NONLINEAR PERIODIC MEDIA: ANALYSIS AND APPLICATIONS

Udine, June 21 - 25, 2010
Application Form
(Please print or type)

Surname _____

Name _____

Affiliation _____

Address_____

_____

E-mail _____

Phone_____Fax_____

Method of payment upon receipt of confirmation (Please check the box)

The fee of Euro 700,00 includes IVA/VAT tax and excludes bank charges

❑ *I shall send a check of Euro* _____

❑ *Payment will be made to CISM - Bank Account N° 094570210900, VENETO BANCA - Udine (CAB 12300 - ABI 05418 - SWIFT AMBPIT2M - IBAN CODE IT83Z 05418 12300 09457 0210900).*
Copy of the receipt should be sent to the secretariat

❑ *I shall pay at the registration counter with check, cash or VISA Credit Card (Mastercard/Eurocard, Visa, CartaSi)*

IMPORTANT: CISM is obliged to present an invoice for the above sum. Please indicate to whom the invoice should be addressed.

Name _____

Address _____

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C.F.* _____

VAT/IVA* No_____

(*) Only for EU residents or foreigners with a permanent business activity in Italy.

Only for Italian Public Companies

❑ *I ask for IVA exemption (ex law n. 537/1993 - art. 14 comma 10).*

Privacy policy: I understand that data received via this form will be used only to provide information about CISM and its activities, within the limits set by the Italian legislative decree no. 196/2003 and subsequent amendments.
Complete information on CISM's privacy policy is available at www.cism.it.

I have read the "Admission and Accommodation" terms and conditions and agree.

Date _____ Signature _____